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GEOPHYSICS.—*Hypotheses on the development of the earth.*[1] B. GUTENBERG, Frankfort a/M. (Communicated by W. D. LAMBERT.)

The hypotheses that have been made as to the evolution of the earth involve a great many assumptions. In general there are four groups of these: the condition of the earth at the moment when the assumed forces began to act, the forces themselves, the mode of action of the forces and the condition of the interior of the earth today.

The usual method has been to search for a single force that might have effected all the changes in the earth's crust, and then to try to explain all of them by this one force. But that method, of which the best example is the hypothesis of contraction, is not sound. We must try to find out all the forces that *can* produce changes in the structure of the earth and the effects themselves. Only by applying this method can we solve our problem.

The researches on the forces that act have given the following results. We have:

Chemical forces and gravity: They formed the different shells of the earth and the changes due to chemical causes continue to occur in the crust of the earth.

We have *cosmical forces:* They are difficult to state. The most important are the tidal forces, which seem to have caused the separation of the moon from the earth.

Forces, the importance of which seems to have been overlooked are those caused by *the deviation of the earth's crust from hydrostatic pressure.* The higher continents try to move toward the oceans. These forces are of the order of 10^9 dynes per square centimeter (dynes/cm^2).

[1] Received November 26, 1929. These hypotheses are to be more fully explained and developed in the *Handbuch der Geophysik*, Band 3.

Other important forces are those caused by the *cooling of the earth* and the *crystallizing of the matter* in the earth's interior. Both together effect a contraction of the circumference of the earth of the order of 2 cm. in a century.

Movements of masses, which disturb the equilibrium of the earth's crust, are caused by *erosion* and *sedimentation.*

The difference of height between the center of gravity of the continents and the matter that forms the bottom of the oceans causes the "*Polflucht*" forces, which strive to move the continents against the equator with a force of the order of 10^7 dynes/cm.^{2}.

To the greater forces belong, finally, the *stresses caused by movements of the earth's crust* relative to the axes of the earth.

All other forces seem to have no influence on the great changes in the figure and the state of the earth. This seems to hold in the case of the forces causing a westerly drift which are due to tidal friction, and, according to Schweydar,[2] to the precession of continents. In the latter case the complete analysis seems not to have been made, and it appears to me to be not impossible that such a force is very small or does not exist at all. Local chemical and physical occurrences are the causes of local volcanic events. Finally small stresses are caused by the movements of the poles with a period of one year and the Newcomb period, by the changes of air pressure, by tides and changes of the water level, by formation and melting of ice, by denudation and other similar forces. They have only a little effect. In some cases they are the "trigger" forces that cause breaking of the earth's crust and earthquakes, and in others they cause changes of level, for instance the uplift of Scandinavia.

The original state of the earth is unknown, but we can suppose that at an early time it was a hot amorphous body the crystallizing point of which was nowhere attained and which possessed relatively little strength. Nevertheless even at that time the incompressibility and rigidity might have been of the same order as today.

Now gravity acted on the matter and caused the heavier material to be pushed down near the center. In addition there was a chemical separation which, according to Goldschmidt,[3] acted in a similar manner as the processes taking place in a blast furnace. Both events together caused the division of the matter into the core, the intermediate layer and the mantle. In subsequent time the difference of density between core and intermediate layer prevented the mixture

[2] W. SCHWEYDAR. Zeitschr. Ges. Erdkunde (Berlin) 1921: 123.
[3] V. M. GOLDSCHMIDT. Naturwissenschaften 10: 918. 1922.

of these two parts and the existence of currents between them, and we may suppose that the core of the earth is today in the same state as after its formation. In the outer shell, however, currents might have been caused by thermal and chemical events, which continue today.

At an early time when this occurred, the tides of the earth caused by the sun seem to have come into resonance with the period of free vibration of the earth, and, according to the researches of Jeffreys,[4] it seems possible that in this way one tide rose so high that a portion of the earth was torn away and formed the moon. In the region where it was formed, the outer shell of the earth was removed, hot magma rose from the deeper parts to the earth's crust which had cooled to such a degree that its strength was great enough to prevent currents. Before the formation of the moon, the earth's crust probably had been nearly in a hydrostatic equilibrium. Now this was disturbed, and from that moment we have one part of the earth's crust with a sialic shell and another part without it, where the moon was removed from the outer shell. The bottom of the Pacific seems to be the remaining part of this region which was denuded of sial, while other parts are still covered by sial.

The sialic part of the earth's crust must have a higher surface than the region from which the moon has been removed, because the matter of the deeper layers which entered the gap was heavier. These depressed parts of the earth's crust were filled by water which had condensed and caused a sinking down of the bottom of the ocean and uplift of the continental parts, so that the difference of height between ocean and continent grew larger.[5] Now the forces that tend to bring about equilibrium of the earth's crust increased. They are given by the following formula:

$$P_{max.} = (\rho - 1) \cdot g \cdot h = 2 \cdot 10^3 \cdot h \text{ dynes/cm.}^2$$

where P = hydrostatic pressure; ρ = average density of the rocks; g = gravity; and h = average height of rocks above the average height of the bottom of the sea, the water of the latter being assumed to have the depth h and $\rho = 1$; the configuration of the coast is without influence.

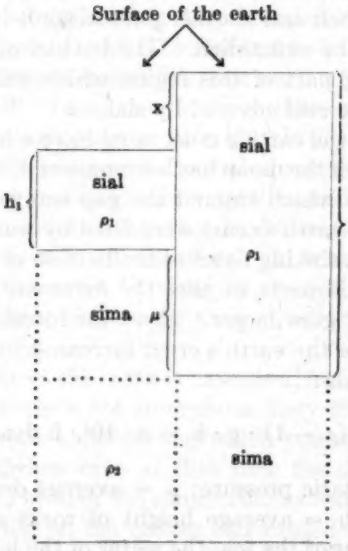
At the time before these forces caused an increase of the continental part of the earth's crust, the height of the continents above the bottom of the ocean was probably greater than today, but even if we accept

[4] H. JEFFREYS. The Earth. Ed. 2, Cambridge, 1929.
[5] Cf. T. GESZTI. Gerland's Beitr. Geophys. 22: 353. 1929.

5 km., we get $P_{max} = 10^9$ dynes per square centimeter. The average strength of the earth's crust (cf. Jeffreys, note 4) today is of the order of $5 \cdot 10^9$ dynes/cm^2. It is therefore to be expected that in the course of time the continental matter in the regions with less strength would flow and spread. This event must have occurred in such a manner that the isostatic equilibrium was maintained, that is to say, for any two arbitrarily chosen columns with a height Z of the order of 100 kilometers,

$$\int_0^h \rho \, d\, Z$$

must have the same value. In the case of a homogeneous layer of sial overlying a homogeneous mass of sima with densities ρ_1 and ρ_2 respectively, as shown in the accompanying diagram, the following relations must exist:



$$\mu \rho_2 + h_1 \rho_1 = h_2 \rho_1 \quad \mu \rho_2 = \rho_1 (h_2 - h_1) \quad \mu \rho_2 = \rho_1 (h_2 - \overbrace{h_2 + x + \mu}^{h_1})$$

$$\mu : (x + \mu) = \rho_1 : \rho_2 \quad \mu : x = \rho_1 : (\rho_2 - \rho_1)$$

Then, since ρ_1 is much greater than $\rho_2 - \rho_1$, μ is much greater than x; in other words, in places where the layer of sial has grown thinner, this must generally happen in the lower parts where sima must enter.

Now the researches of Taylor, Wegener, Köppen[6] and others show that observations of many different sorts are readily explained only with the assumption that all continents were one entire complex in earlier geological times and have moved apart one from the other and do so even today. But contrary to Wegener,[7] I think that this happened by flowing as an effect of hydrostatic pressure and not by fissuring.[8]

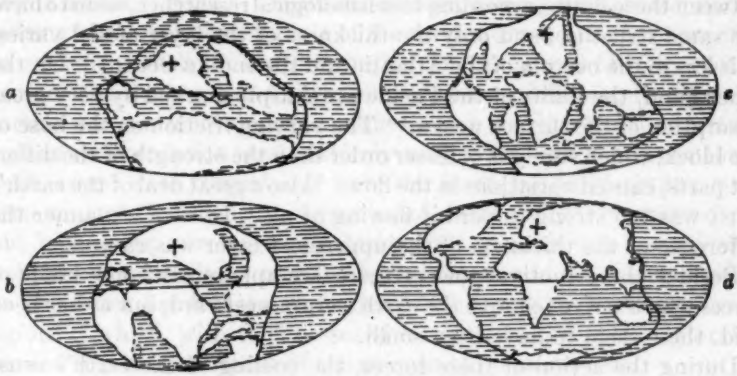


Figure 1. Development of the continents (+ = Europe)
a. Carboniferous; *b*. Cretaceous; *c*. Eocene; *d*. Quaternary

We do not know what was the position of the continental block immediately after the formation of the moon. The equilibrium of the earth's crust was completely disturbed and stresses were caused which tended to come into equilibrium. This must have been a period of great movements. There is not enough climatic evidence that can be used to determine the position of the different parts of the earth's surface. The first geological epoch in which some quiet seems to have been restored was the Carboniferous. All climatic evidence seems to show, as Köppen, Wegener and others have found, that at this time nearly the whole complex of continents was situated in the southern hemisphere of the earth. (Fig. 1.) Under the action of the hydrostatic forces of the earth this block began to drift apart. At the same time the *Polflucht* forces tended to move the entire block over its base in such a manner that the integral of all these forces became zero, so that the masses of the continental block situated north of the equator

[6] KÖPPEN UND WEGENER, Die Klimate der geologischen Vorzeit. Berlin, 1924.
[7] A. WEGENER. Die Entstehung der Kontinente und Ozeane. Aufl. 4, 1929.
[8] B. GUTENBERG. Gerland's Beitr. Geophys. 16: 239. 1927; 18: 225. 1927.

were of the same order as the masses south of it. This state now has been reached with some approximation. The movements must cause high mountains at the borders of the block, as actually observed.

In this case we must take into consideration that today the limits of the continental block are given by the western coast of North and South America, Antarctica, New Zealand, the Tonga Islands, New Guinea, the Philippines and Japan. All parts of the earth's crust between these limits, according to seismological researches, seem to have the same structure, and only the thickness of the layer of sial varies. It is less in the bottom of the Atlantic and the Indian Oceans. On the other hand, the limits of the Pacific are sharply marked by very great absorption of the surface waves.[9] The varying friction on the base of the block, which surely is of lesser order than the strength of the different parts, caused variations in the flow. Also a great deal of the earth's crust was too strong to permit flowing at all. In such a manner the difference of the thickness of the uppermost layer was caused.

Besides these motive powers there are apparently some kinds of forces which strive to move the earth's crust westward, but as has been said, these seem to have been small.

During the action of these forces, the cooling of the earth's crust was proceeding, crystallization was going on, and the deeper layers of the earth's crust (say between 50 and 200 kilometers, as a first approximation) contracted, so that the outer shell had to fit the diminishing base. The stresses arising in this manner accumulated. Only in the outermost parts of the shell can they be equalized by breaking and movements of the broken parts. In the deeper regions, in general, there are movements by flow which begin as soon as the forces exceed the strength, which differs in different parts of the earth's crust. The smallest strength is in the weak parts of the earth, which are the boundaries of the different layers, notably the borders of the Pacific. It is there that the movements compensating the stresses caused by contraction must be most noticeable. These movements of shrinking are accompanied by outflow of magma. Indeed the whole borders of the Pacific are covered by volcanoes and signs of magmatic action have occurred at different geological epochs.

But other factors have also influenced the events. There exist a great many other forces[10] which cause stresses superimposed upon those caused by cooling. Where all these stresses act in the same direction, movements must reach their maximum. On the other hand

[9] B. GUTENBERG. Handb. Geophys. 4: Lief. 1. 1929.
[10] B. GUTENBERG. Handb. Geophys. 3: Abschn. 1. 1930.

the strength of the earth's crust was influenced by different events. Movements of the poles, or movements of the earth's crust relative to its base, caused regressions and transgressions, as the water at once assumes any new position of equilibrium. Furthermore, sedimentation was greatest in the regions of transgression, and caused new sinking of the bottom of these regions. In all places where sedimentation occurred, there must have taken place compensating movements of flow in deeper regions. The masses pressed down reached hotter parts, melting began below such parts of the earth's crust, and a geosyncline, an extremely weak zone, was formed. One recognizes that in such a manner the weakness and the strength were modified in the different parts of the continental block. Especially is it evident that in certain regions sedimentation was relatively very great, and that even there weak zones were formed. If now the forces assumed greater proportions and the strength was exceeded, these zones were pressed out and mountains were formed. During all these events isostasy was maintained as nearly as possible by movements in the deeper layers. On the other hand there originated thick layers of sediments, vast regions of which, with thicknesses of many kilometers, being laterally pressed together to depths of ten or even more kilometers.

I think that in this way all attributes of geosynclines are explained in the most simple manner and in connection with the great events of the history of the earth's surface. The material of these geosynclines being pressed out forms, as we have seen, a smaller but thicker region of rocks. Therefore it is not permissible from the thickness of these layers to draw conclusions about the original thickness, and it is not necessary to base calculations upon sedimentation of so great a thickness as has usually been done.

After this event the geosyncline has lost its mobility and the weak zone has disappeared. The mountains thus formed are very steep, denudation has abnormally great values, and sedimentation increases near the new coast, the conditions there being then favorable to the formation of a new geosyncline, running nearly parallel to the preceding one.

Now we will turn back to the forces that press out the weak zones and form the geosynclines. First we have the stresses caused by shrinking of the earth's crust. They are superimposed on forces caused by the *Polflucht*, which press together the northern and southern parts of the continental block in the neighborhood of the equator, where they tend to produce an elevation with a height of twenty meters. The stresses caused in this way are entirely insufficient to produce any

motions as they are only of the order of one hundredth of the strength, but they enhance the effect of the stresses caused by the contraction, with the result that these stresses reach their maximum to the north and to the south of the equator and are directed against it.

Generally the first motions caused by these stresses must arise in a geosyncline in the neighborhood of the equator, and must produce mountains nearly parallel to it which extend over large regions. In these regions the geosynclines were pressed out, as has been pointed out. This happens not only at the outside of the earth's crust, but also on the inside, approximately according to the laws of isotasy. *Unterströmungen*,—currents in the deeper layers,—were produced to maintain the equilibrium, as nearly as possible. The motion extended over larger regions, but by degrees the stresses caused by contraction became exhausted. The *Polflucht* forces remained unaltered. They could affect some motions in the disturbed regions, but finally all was solidified, strength reached its normal value, the motions ceased, the initial conditions recurred, an epoch of the revolution of the history of the earth had passed and, during subsequent time, only epirogenic movements took place.

In the following epochs the stresses caused by the cooling of the earth accumulate anew and finally a new orogenic period begins, but now according to the changes of the position of the equator and other regions in the neighborhood of the new equator. These parallel changes of the position of the equator and the zones of mountain building can be easily traced in the case of Europe, where both travelled southward during the later geological epochs.

My sketch of the evolution of the earth has come to its end. I think I have shown how it can be explained on the basis of forces that must be expected according to theory, and is in good agreement with a great deal of observation. Let me now put a last question: What will be the further evolution of the earth? The continental block is at present lying nearly symmetrical to the equator. Therefore it is not probable that great movements of this block as a whole will arise. In other words, it is improbable that the poles will make greater movements relative to the earth's crust. Indeed observations of Lambert[11] and others have shown that these movements today are very small and that their direction is opposite to that we have found for the preceding geological epochs. The changes of climate during the last epoch, the glacial period, have nothing to do with our problem. They are

[11] W. D. LAMBERT. Astron. Journ. **34**: 107. 1922.

caused by changes of the astronomical elements of the earth (cf. Köppen and Wegener, footnote 6).

The motions caused by hydrostatic pressure continue, though diminishing a little according to the degree of spreading out of the continental layer. The distances between the different points of the continents must increase and the surface of the stretched regions must continue to sink. Probably the sinking of the western coast of Europe is an accompanying effect of these events. Finally stresses caused by the shrinking of the earth and the *Polflucht* forces accumulate until a new orogenic period begins and new mountain building sets in, in the neighborhood of the equator. It may be stated that there is a great difference between the events in the interior of the continental block,—for example, in Europe, where *Polflucht* forces and shrinking work together —and in the borders of the block,—the coast of the Pacific, where as in the case of America the shrinking stresses are compensated together with the hydrostatic movements which continue to act nearly unaltered.

BOTANY.—*A long lost* Phlox.[1] EDGAR T. WHERRY, Washington, D. C.

The herbarium of Samuel B. Buckley, now at the Missouri Botanical Garden in St. Louis, includes a specimen of *Phlox* labelled "Phlox No. 2, Mts. White Sulphur Springs, Va. June, 1838." This bears a superficial resemblance to *P. pilosa*, but closer examination shows that Buckley was right in declining to ascribe it to that or any other recognized species. How this striking plant escaped the attention of the many botanists who visited the region around White Sulphur Springs (now in West Virginia) during the subsequent three quarters of a century is a mystery, but the fact remains that it is not included in any collection made during that period to which the writer has had access, nor is it mentioned in Millspaugh's flora of the state. This *Phlox* was first rediscovered by Miss Marian S. Franklin of Lewisburg about 1919, and specimens collected by her near White Sulphur Springs are preserved in the Gray Herbarium (September 4, 1920, in fruit) and the herbarium of the University of Pennsylvania (May 22, 1922). It had been labeled *P. pilosa*, and when I first saw it in the field, during a vacation trip in 1923, the same misidentification was made. Early in June, 1929, on another visit to the region, in the company of Mr.

[1] Received December 15, 1929.

J. E. Benedict, Jr., its relationships were worked out, and several stations for it were discovered. The data obtained justify announcing it as an independent species, which seems appropriately named:

Phlox buckleyi Wherry, sp. nov.

Plant perennial, with one or more decumbent stems 3 to 20 cm. long, each bearing at the tip a closely set group of long narrow evergreen leaves, from the midst of which arises the erect flowering shoot, 15 to 40 cm. tall, with 3 to 7 nodes below the inflorescence; stem glabrous below and increasingly glandular-pubescent upward; leaves glabrate, or the upper more or less pubescent, opposite, the blades thickish, sessile, acuminate; lower leaves linear to somewhat lanceolate or oblanceolate, often ensiform, mostly 50 to 125 mm. long and 2 to 5 mm. wide, the upper ones ranging from short lanceolate at the base of the flowering shoot, to linear-lanceolate, up to 80 mm. long and 8 mm. wide, near the middle, and to broadly lanceolate, 40 mm. long and 12 mm. wide, toward the top; inflorescence a small to moderately large corymbose or somewhat paniculate group of cymes, densely glandular-pubescent; bracts similar to the uppermost leaves, rapidly decreasing in size upwards; pedicels short; calyx 7 to 13 mm. long, the sepals united to about 2/3 their length, tipped with short awns; corolla-limb bright purple, usually near phlox or mallow purple (Ridgway's 65 or 67 b), the eye somewhat paler and often bearing a purple 5-rayed star formed by deltoid patches of slightly deepened color toward the lobe-bases, the tube purplish violet to gray, glandular-pubescent; petals 25 to 35 mm. long, united to 2/3 their length, the tube thus 17 to 23 mm. long, the obovate to nearly orbicular lobes 8 to 12 mm. long and 7 to 10 mm. wide, terminally truncate and entire, slightly erose, or barely emarginate; stamens nearly as long as the corolla-tube, or one sometimes longer, the average distances from tube-orifice to anther tips being respectively 0, 0.5, 2.0, 3.5, and 5.0 mm.; anthers cadmium yellow or essentially so; styles 14 to 20 mm. long, united to within 1 mm. of the tip, the 3 stigmas lying in the midst of the anthers, or slightly exserted; ovules usually 2, but sometimes 1 or 3 per cell; capsule about 5 mm. long.

Type locality, White Sulphur Springs, Greenbrier County, West Virginia; type specimen collected by S. B. Buckley in June, 1838, in herbarium of Missouri Botanical Garden.

Thus far, six localities for *Phlox buckleyi* have been found, which, from west to east, are as follows: Greenbrier County, West Virginia,—¾ mile southeast of Caldwell, ¼ mile south of White Sulphur Springs station (probably the site of Buckley's original collection), and 1½ miles southeast of White Sulphur Springs village; Alleghany County, Virginia,—1 mile north of Alleghany station, 1½ miles southeast of this station, and 1 mile southwest of Longdale Furnace. The maximum diameter of its recognized range is thus barely 40 miles (65 kilometers). The normal habitat at all these places is a thinly wooded slope toward the base of a hill of Devonian shale, the soil being usually a humus-rich gravel of subacid reaction.

Figure 1. *Phlox buckleyi* Wherry.

This very distinct species belongs in a different section of the genus from *P. pilosa*, which it resembles at first sight, as shown by the decumbent stems with evergreen terminal leaves, the well-united sepals, and the long stamens and styles. It is actually most closely related to *P. ovata*, which grows in the same region, but differs in the much narrower leaves, the abundant glandular pubescence, and the double ovules; moreover, even where intimately associated, the two show no tendency to intergrade or to hybridize. Its aspect is brought out by the two photographs reproduced on page 27, the upper representing a habitat view taken at the locality southeast of Caldwell, West Virginia, June 1, 1929, and the lower a group of pressed specimens from the same place, × $\frac{1}{10}$. The highly distinctive tufts of ensiform leaves suggest, as a common name for the species, Swordleaf Phlox.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

PHILOSOPHICAL SOCIETY

The 995th meeting was a joint meeting with the Geological Society of Washington, and was held in the auditorium of the Interior Department building, Wednesday, October 23, 1929, with Vice-President LAMBERT of the Philosophical Society in the chair.

The program of the evening consisted of an illustrated address by Dr. BENO GUTENBERG, Professor of Geophysics at the University of Frankfurt-am-Main, on *"Some hypotheses on the development of the Earth's crust"* (published in this number). It was discussed by Messrs. BOWIE and HECK.

The 996th meeting was held in the Cosmos Club Auditorium, November 9, 1929.

The program of the evening consisted of two illustrated communications:

P. R. HEYL, V. L. CHRISLER, and W. F. SNYDER. *Absorption of sound at oblique angles of incidence.*—The effect of oblique angles of incidence upon the sound absorption of a substance is a point concerning which there has been up to the present time no experimental evidence. PARIS has published a theoretical discussion leading to a formula which indicates that as we pass from normal incidence to grazing incidence the absorption should increase considerably, being about 50 per cent greater at 60°.

Experiments recently performed at the Bureau of Standards appear to show that the absorption of sound is independent of the angle of incidence.

It seems probable that the error in Paris' discussion is due to the fact that sound absorption is produced by friction, converting sound energy into heat. Friction is likely to produce rotational motion in fluids, and where rotational motion exists there can be no velocity potential. In consequence, the customary differential equation for sound motion, in which the dependent variable is the velocity potential, fails to hold in a region of sound absorption. (*Authors' abstract.*) Discussed by HUMPHREYS, HULBURT, LITTLEHALES, GISH, PAWLING, and others.

E. O. HULBURT: *Ions and electrical currents in the upper atmosphere.*—It is assumed that the ionization in the upper atmosphere is caused by the ultraviolet light of the sun and that the ion and electron densities at noon at the equator are those required by the theory of wireless wave propagation. From the laws of recombination of the ions and the diffusion and drift of the ions in the earth's magnetic and gravitational fields the distribution of the ions over the earth is worked out. This distribution turns out to be that required by the diamagnetic theory of the solar diurnal variation of the earth's magnetism. The gravitational drift currents are found to flow mainly along the parallels of latitude in the following way: On the daylight hemisphere (1) a current sheet flowing eastward in the levels above 150 km. which at the sunrise and sunset longitudes divides into two sheets; (2) one of these flows westward on the day side of the earth underneath (1) in the levels below 150 km., and (3) the other sheet continues eastward in the upper levels around on the night side of the earth. The current is mainly between the fortieth parallels of latitude, north and south, and falls to lower values at the higher latitudes. The total currents in the three sheets are about 10^7, 8×10^6 and 2×10^6 amperes, respectively. The east and west daytime current sheets subtract from each other leaving in effect an eastward current of about 2×10^6 amperes flowing around the earth all the time. This causes a magnetic field agreeing in magnitude and type with that obtained by Bauer in his 1922 analysis of the magnetic field of the earth of external origin.

As a result of the drift currents, the sunset longitude of the earth is at a potential of several hundred volts above that of the sunrise longitude. This electric field combined with the earth's magnetic field causes the ions and electrons on the night side of the earth to drift upward with velocities of order 10^2 cm. sec.$^{-1}$. The ions and electrons move into regions of lower pressure and therefore do not recombine as fast as they otherwise would. This removes a difficulty from an earlier calculation which yielded too great a night-time rate of disappearance of the free charges. The upward drift of the ionization causes a rise of the Kennelly-Heaviside layer which is, partially at least, compensated by the fall due to the cooling and contraction of the atmosphere at night, and is complicated by the diffusion of the ions. It is difficult to say how much of the night-time rise of the layer observed in experiments with wireless rays may be genuine rise and how much may be an apparent rise due to delayed group velocities, or to other causes. (*Author's abstract.*) Discussed by GISH, L. H. ADAMS, and others.

EDGAR W. WOOLARD, *Recording Secretary pro tem.*

GEOLOGICAL SOCIETY

455TH MEETING

The 455th meeting was held at the Cosmos Club November 13, 1929, President CAPPS presiding.

Program: E. W. BERRY: *Arctic climates as indicated by fossil plants, and a possible explanation.* Discussed by DAVID WHITE.

REMINGTON KELLOGG: *Migration of marine mammals in relation to climate.*

W. J. HUMPHREYS: *Factors of climatic control.*

456TH MEETING

The 456th meeting was held at the Cosmos Club November 27, 1929, President CAPPS presiding.

Informal communications: DAVID WHITE called attention to the excellent exposure of Cretaceous and Tertiary sediments along 16th Street above Florida Avenue.

Program: H. H. BENNETT: *Contributions by the Bureau of Soils to the problem of erosion.* The farm and grazing lands of the country are not inexhaustible, as vast areas are subject to severe impoverishment and destruction by unrestrained soil erosion. The normal process of soil erosion of undisturbed land is insignificant compared to the accelerated washing of the land due to the removal of forest and brush growths, the breaking of ground and the matted sod of the prairies, and the destruction of herbage by overgrazing. Erosion, due to the latter causes, operates chiefly on the top soil, the most productive part of the land, and the amount of wastage depends on the soil, the slope, the amount and rapidity of rainfall, the crops grown and the methods of cultivation. On some highly erosive lands as much as one inch of soil may be removed in one year and it is believed that not less than one billion five hundred million tons of rich soil matter are swept out of the fields each year. The amount of plant food washed out of the fields each year is more than twenty times the annual loss by the crops taken from those fields. That lost through crops can be replaced by fertilizers and soil improving crops but that removed by erosion is irreplaceable. Experimental erosion and moisture conservation stations are being established in a number of major regions of varying soils and climate and various structures such as terraces and dams, as well as various types of vegetation, will be tested under field conditions in attempts to slow down the losses.

Discussed by GOLDMAN, WHITE, PEPPERBERG, and RUBEY.

C. N. MUNNS: *Contributions by the Forest Service to the problems of erosion.* Discussed by RUBEY and THOMPSON.

C. S. HOWARD: *Suspended matter in the Colorado River.* Water-Supply Paper 636-B of the United States Geological Survey describes the methods of sampling and the results obtained in a study of suspended matter in the Colorado River from 1925 to 1928. These results, with additional data for 1928–1929, show that the most rapid fluctuations and the largest loads occurred during the periods of the summer floods when a large proportion of the flow of the river was caused by rains in the semi-arid portion of the drainage area. The daily load of suspended matter at the Bright Angel station in the Grand Canyon ranged from 3,700 to 20,700,000 tons. The annual load at the same station ranged from 189,000,000 tons in the lowest year to 443,000,000 tons in the highest year. (*Author's abstract.*) Discussed by BAKER, BENNETT, MUNNS, GOLDMAN, RUBEY, THOMPSON, COLLINS, and ALDEN.

457TH MEETING

The 457th meeting was held at the Cosmos Club December 11, 1929, President CAPPS presiding. Vice-President G. R. MANSFIELD took the chair during the presentation of the presidential address: *Glaciation in Alaska.*

37TH ANNUAL MEETING

The 37th annual meeting was held at the Cosmos Club after the adjournment of the 457th regular meeting, President CAPPS presiding.

The annual report of the Secretaries was read. The Treasurer presented his annual report showing an excess of assets over liabilities of $1,205.54 on December 10, 1929. The auditing committee reported that the books of the Treasurer were correct.

The results of balloting for officers for the ensuing year were as follows: *President:* G. R. MANSFIELD; *Vice-Presidents:* O. E. MEINZER and F. L. HESS; *Treasurer:* H. G. FERGUSON; *Secretaries:* JAMES GILLULY and C. H. DANE; *Members-at-Large of the Council:* W. D. COLLINS, HERBERT INSLEY, H. D. MISER, G. B. RICHARDSON, and W. C. MANSFIELD; *Nominee as Vice-President of Washington Academy of Sciences representing the Geological Society:* S. R. CAPPS.

A. A. BAKER, JAMES GILLULY, *Secretaries.*

SCIENTIFIC NOTES AND NEWS

Mr. and Mrs. W. H. HOOVER and Mr. F. A. GREELEY have returned in November from their three years' occupation of the Smithsonian solar observing station on Mount Brukkaros, South West Africa.

Professor A. S. HITCHCOCK has returned from Africa, where he obtained large collections of grasses.

The collections of the Division of Fishes, U. S. National Museum have been greatly enriched by the receipt of a large number of Chinese fishes from Mr. A. DEC. SOWERBY and Dr. D. C. GRAHAM.

Dr. E. P. CLARK, research chemist of the Interstate Cottonseed Crushers' Association, and Dr. HERBERT L. J. HALLER, associate in the department of chemistry of the Rockefeller Institute for Medical Research, have accepted appointment in the insecticide division of the chemical and technological research unit of the Bureau of Chemistry and Soils. As organic chemists in the field of insecticides, they will investigate the structure of substances occurring naturally in certain tropical plants which are characterized by high toxicity to fish and which are believed to have promising possibilities as insecticides. When the structure of such compounds has been sufficiently investigated, attempts will be made to synthesize them or certain of their derivatives. The effect of all compounds isolated or synthesized will be physiologically tested upon fish, tadpoles, insects, and animals, as it is important to know their toxicity to man as well as their effect upon insects.

Professor C. C. GHOSH, Entomologist in the Agricultural College at Mandalay, Burma, paid a brief visit to Washington in December during the course of a trip around the world.

W. V. KING, of the Bureau of Entomology, who has been for seven months investigating mosquitoes in the Philippines for the Rockefeller Foundation, has been studying the mosquito collections in the National Museum.

Professor JOSIAH BRIDGE, of the School of Mines of the University of Missouri, is studying Ozarkian gastropods at the National Museum in connection with the work of the Missouri State Bureau of Geology and Mines and in cooperation with members of the U. S. Geological Survey.

Dr. C. E. RESSER has been appointed Curator of Stratigraphic Paleontology in the National Museum. Dr. Resser has been connected with the Division of Paleontology since 1915.

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